From Editor:

After reading the reviews, I have some additional thoughts as well.
1. Regarding the table of instrument comparisons, I strongly recommend removing any subjective rows, like "risk of exposure" or "versatility."

This has been done along with the suggestions of adjustments to Table 1 from Reviewer 1 (see below).

2. The purpose of AMT articles is to describe new instruments and measurements. While objective comparison to other methods is valuable, the focus should be on the technique/instrument itself, not how much better or worse it is than other methods (unless it were a true intercomparison study, which this is not). Removing some of the salesman-like language would make this paper more palatable for your readers. Let the numbers speak for themselves.

Agreed. All of the language of this nature has now been removed per the specific suggestions of the reviews below.

From Reviewer 1:

General Comment 1

The table has been improved, however, there are still some issues: • The uncertainty should be a value reflecting the percentage uncertainty of a single measurement (i.e. ±10%) and should be linked to a study that has measured this. This value is key to assessing the relative performance of methods. • Please present the Hardware Cost of the FAST method as described in the paper and not a potential number based on sensors not used in this study. The value currently presented “$2k - $50k” is a range orders of magnitude apart and provides no useful information. Please only report the cost of the hardware as presented in this study. • Again, size and set up time of the FAST method should reflect the system reported in this study and not a future untested system. How long did it actually take you to install a fan, sonic anemometer, Picarro etc and get them all running? • I am a bit confused as to what “Safety” means as the caption reads “likelihood of an operator not being exposed to…”. Does “low” mean a low likelihood of not being exposed, therefore a high likelihood of being exposed? Regardless, to me it seems that the GPM and FAST should have the same likelihood of being exposed to gas. Also, one key flaw of the FAST method is equipment needs to be installed upwind and downwind of the source, therefore, likely exposed to gas. In contrast, the Hi-Flow, OGI and Dynamic chamber can be installed from an upwind location and away from the plume. Therefore I would assume the FAST method is high risk while the Hi-Flow, OGI and Dynamic chamber are low risk. • I also do not agree that the Hi-Flow has low versatility, this is a small, self-contained unit that has been used to measure methane emissions on the top of condensate tanks on production sites, so it can go almost anywhere. The results presented later in the paper suggest the fan has to be correctly positioned for the FAST method to be useful, therefore, it's not going to be very versatile for emission points that are hard to reach (most emissions on abandoned wells are difficult to reach).

These are all very valid concerns for Table 1. The table has been updated and simplified to minimize confusion below. The non-quantitative rows were removed per the suggestion of the editor as well.

Method	**FLIR Camera**	**SEMTECH HI-Flow 2**	**Static Chamber**	**Dynamic Chamber**	**GPM**	**Vent**	**UAV**	**OTM-33a**	**FAST**
Hardware Cost	>$50K	~$40K	>$400	>$400	>$5K	~$50K	>$50K	>$10K	$50K*
Range (g/h)	N/A	<1-30,000	>0.1	>0.1	>100	>100	>50	>50	>1
Uncertainty	N/A	±10%	-50%, +100%	±15%	±40%	N/A	N/A	±70%	±50%
Size (L)	~0.3	~15	~20	~20	~50	N/A	~40	>1,000	~50
Measuring Time (min.)	~2	~3	>30	>30	>10	>30	>30	>10	~3
Setup Time (min.)	~5	~5	>10	>10	>10	>10	>30	>30	~30

Table 1: Comparative assessment of commercial (FLIR, SEMTECH Hi-Flow 2, Vent) and research (Chamber, GPM, UAV, OTM-33a) methods used to monitor fugitive methane leaks from orphaned wells. Hardware costs, detection range, accuracy, size, labor and safety are compared for each technology. *The FAST method in this study is currently limited by the high cost of laser trace gas sensors (Picarro, Aeris, etc.) that can be reduced significantly by using cheaper non-laser sensors (i.e. Gas Rover) used in chambers.

General comment 2 Can you please share the caveats that you have added to the manuscript including the line numbers. As you have not included these details in the response I cannot comment if this issue has been addressed.

Yes, here are some comments/caveats we added:

Abstract L22: "...low-cost, portable, fast and safe alternative to existing methods with reasonable estimates of orphaned well emissions over a range of leak rates below 40 g/h and within certain geometric and atmospheric constraints."

L93: "…provide reasonable estimates of orphaned well emissions under reasonable meteorological conditions."

L157-162: "A key assumption of this study is that the effective plume width (σ_0) derived in Halloran et al. (2014) for smoking oil plumes is applicable to methane dispersion from orphaned wells. While the MDB fan generates turbulent transport similar to Halloran et al., differences in the physical properties of smoking oil and methane—such as buoyancy, diffusion rates, and emission dynamics—could lead to deviations in plume behavior. These potential differences underscore the need for additional experiments designed specifically for methane to validate the use of (σ_0) under these conditions and further refine the FAST method's applicability."

L456-462: "The results for Hooper #41 highlight challenges in measuring methane emissions from variable wells and suggest potential limitations in the FAST method. The variable leak rate led to significant uncertainty in SEMTECH readings (±95.47 g/h), while the FAST method provided more stable estimates (10 ± 10 g/h). However, the fan setup likely failed to fully entrain the emitted gas into the airflow directed toward the sensor, potentially leading to an underestimation of emissions, as supported by SEMTECH data and Figure 10. This limitation is particularly critical for wells with low-height emissions, such as Hooper #41. Future work could address this limitation through controlled release experiments at different heights to optimize the fan and sensor configurations for capturing low-lying plumes."

General comment 3 The addition of section 3.1 is good and clearly explains what was missing in the previous iteration. A necessary addition is the uncertainty of KFAST, this is currently missing and essential to the study. Please add this.

This discussion was added in L347-362 on the recent submission. See below.

"By using the known values of Q from stoichiometry (source rate) and the measured values of C and u during the controlled release experiment, the experimentally determined values of K_{FAST} for different filter angles and fan speeds are estimated via Equation 3. By inverting Equation 3 to solve for K_{FAST},$K_{FAST} = \frac{\overline{C_{CL}}\ \overline{u_{CL}}}{Q}$ where the known value of Q and 10 minute averages of C_{CL} and u_{CL} are used to estimate K_{FAST}. The resulting values for K_{FAST} are shown as the slopes of the lines in Figure 7 along with the uncertainties resulting from standard error estimates on the linear regression used to generate the line of best fit. As expected, the No Fan scenario has a much higher value of K_{FAST} with higher overall uncertainty due to the variation of the natural wind direction and speed. Without filtering the data by wind direction, the K_{FAST} values are larger (likely due to more dispersion from crosswinds). Furthermore, K_{FAST} values at the low and high fan speeds do not agree, although K_{FAST} is theoretically independent of fan speed (per Equation 4). As more and more crosswind is filtered (Filter Angle approaches 360 degrees), the low and high fan speeds converge to a K_{FAST} of around 0.19 m^2, as expected. All fits are done with a 0 intercept and standard errors are used to estimate the uncertainty of K_{FAST}. Table 4 shows the resulting experimentally determined values of K_{FAST} and their corresponding uncertainties which were used to estimate emissions and corresponding uncertainties from field measurements."

Filter Angle	No Fan	Low Fan	High Fan
0 Degrees	1.70 ± 0.52	0.47 ± 0.03	0.27 ± 0.08
180 Degrees	1.63 ± 0.51	0.28 ± 0.01	0.24 ± 0.03
300 Degrees	1.11 ± 0.37	0.20 ± 0.01	0.19 ± 0.01

Table 4: Values of K_{FAST} in m^2 and their associated uncertainties under various filter and fan conditions determined from the Richmond controlled release experiment.

General comment 4 The response is mostly OK apart from the statement "Despite this, the FAST method shows promise for measuring variable emissions more consistently than SEMTECH.". There is no evidence that the emission from Hooper #41 is constant and abandoned wells have shown to have variability on very short timescales. I suggest this sentence is removed.

Thank you, this sentence was removed.

General comment 5 Response is good. Specific comments All ok apart from those listed below.

Thanks.

Original L513-518 – Now P 25 starting "Furthermore, the type…"
This makes a very big assumption that lower cost sensors will have the same accuracy/precision as the Picarro and are sensitive enough to be used to measure ppm-level concentrations. In nearly all cases, this is not true. The NDIR and Gas-Rover will not be able to measure at low concentrations (< 10 ppm) while the Nikira Labs' Portable Methane Gas is still quite expensive (tens of thousands). This whole part of the discussion is highly speculative and should not be included, i.e. from "Furthermore," to "[Portable Methane Analyzer]."

While this is still speculative, it is actually part of undergoing work we are doing now and mentioned as "future work" explicitly. This was added in response to another reviewer's request for more specific technologies, which we have now removed. We have dialed it back to the following:

"Furthermore, the type of methane sensor can be optimized to a more reasonable price point, as CH_4 signals near sources are typically high (e.g., > 1 ppm for leaks > 1 g/h). Future work will focus on investigating a wide variety of methane detection technologies to identify more cost-effective and reliable solutions for wide-scale FAST method deployment."

L528
Again this is highly speculative. I would suggest the following statement is removed "However, with the aforementioned simplified setup, the FAST method's setup time could be reduced to match that of the SEMTECH, making it more practical for field deployment."

Removed.

"5. Conclusions"
Several sentences within the "conclusions" section are not backed up by any of the findings in the paper. This section should be comprehensively reviewed. For example, "In the case of the highly variable Hooper #41, where SEMTECH struggled with the well's fluctuating leak rates, the FAST method's larger sampling cross-section and volume resulted in overall lower emissions estimates and relative uncertainty. However, the fan-driven airflow may not fully entrain all emitted gas, particularly from low-height leaks, potentially leading to an underestimation of emission rates for such wells." How do you know the Hi-Flow "struggled"? This sentence should be rewritten. The following sentence stating "Future developments in sensor optimization, including the use of more affordable wind and methane detectors, are expected to further enhance its deployment efficiency and accuracy across diverse field conditions. Further testing is being done to optimize the necessary wind and methane sensors to lower costs and maintain accuracy in order to deploy this technology across the U.S. to quantify fugitive emissions." I understand you are trying to convey that the system could be optimized to overcome some of the current shortcomings but it sounds like an advert for a product and shouldn't be included in a scientific paper as it stands. This should be rewritten.

Noted, this has been updated as follows to be clear, concise and non-advertising:

"In the Texas and Oklahoma field campaigns, the FAST method provided accurate and rapid readings under varying environmental conditions, with errors on the order of 95% of the emission rate across different wind conditions and leak rates. In Texas, where wind speeds were low, only the Low Fan setting was used, and FAST results aligned closely with SEMTECH, within 10%. In Oklahoma, higher wind conditions required both Low and High Fan settings to account for greater natural dispersion. At Hooper #41, where emission rates fluctuated significantly, FAST produced lower overall estimates than SEMTECH, likely due to its larger sampling cross-section averaging out short-term variability. However, fan-driven airflow may not fully entrain all emitted gas, particularly from low-height leaks, which could contribute to an underestimation of emission rates in certain cases.

The FAST method offers a potential alternative to existing technologies such as SEMTECH and FLIR for identifying high-priority orphan wells. Its combination of controlled airflow and real-time methane measurement enables rapid assessments suitable for large-scale monitoring. Ongoing research aims to refine wind and methane sensor integration to improve cost efficiency while maintaining measurement accuracy across diverse field conditions and leak rates."